

Uropathogenic *Escherichia coli* (UPEC)

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Background ¹²

Overview:

Escherichia coli (*E. Coli*) is a Gram-negative bacillus and is known to be part of the normal biota of the human body. *E. coli* is a motile and non-spore-forming facultative anaerobe. In primary biochemical testing, it is catalase positive and oxidase negative. Some identifiable features from secondary biochemical testing include lactose fermentation and indole production. *E. coli* is most often found in the gastrointestinal tract but certain strains are known to inhabit the genitourinary tracts as well as natural flora. It is a common cause of gastroenteritis, neonatal meningitis, and several nosocomial infections including UTIs. However, the strains causing UTIs do not originate from the gastrointestinal tract, but instead are strains naturally present in the gastrointestinal systems.

Pathogenesis:

Uropathogenic *E. coli* (UPEC) colonizes the urinary tract after being displaced from the gastrointestinal tract through feces, where it comes in contact with the urethral opening. It moves through the urethra and binds to the uroepithelial cells of the bladder using a type 1 fimbrial activity. UPEC can survive in the urinary tract by neutralizing the lysosome and attaching to uroepithelial cells. UPEC can form biofilm-like clusters called intracellular bacterial communities (IBCs), supporting its colonization further. In certain cases, UPEC will move up the ureters through its motility and enter the kidneys. Within the kidneys, UPEC can bind to the kidney lining and lyse the cells, allowing entrance into the bloodstream.

Signs and Symptoms

Signs and symptoms of UPEC are inflammation of the urinary bladder (cystitis), swelling of the kidneys (pyelonephritis), painful urination, inability to urinate, blood in the urine, nausea, chills, and general discomfort. If the infection has moved into the kidneys, symptoms can further develop into lower back pain, fever, and vomiting. Often, though, especially in young women, UTI infections are asymptomatic or only induce a minor fever, leaving the infection to be undiagnosed.

Diagnosis:

Most UTIs are suspected based off of clinical diagnosis. A clean-catch urine collection will be conducted to measure the amount of bacteria within the urine. A UTI is diagnosed with the amount of bacteria is greater than 10³ bacteria per milliliter of urine. To specifically diagnose UPEC, a urine culture is obtained from the patient which will indicate a UTI. A subsequent blood culture is also necessary to determine Gram-negative rods. A PCR test will ultimately determine what strain of *E. coli* is present.

Prevention:

UPEC infections can be prevented through proper sterilization of hospital equipment, especially urinary catheters. Avoiding the reuse of medical equipment will also prevent introduction of UPEC into the bladder. Another way to prevent UPEC infections is proper education of hygiene practices, especially to younger children, including proper genitourinary care after using the restroom to prevent accidental fecal contamination of the urethral opening. Individuals who have recovered from a UTI need to extra vigilant in monitoring for symptoms within the first 6 months post-recovery, because reinfections are likely with UPEC.

Treatment:

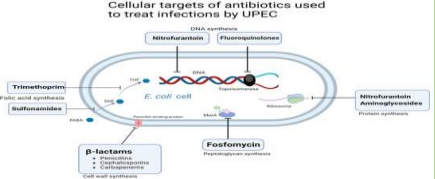


Figure 1: Cell targets of antibiotics used to treat infections by UPEC. (Whelan et al., 2023)

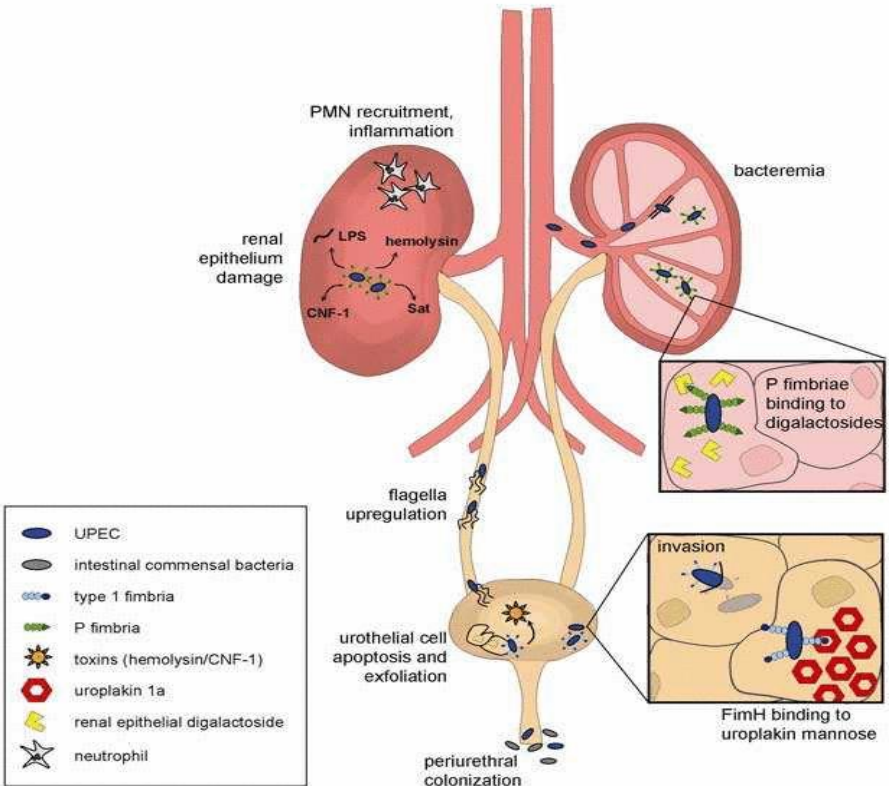


Figure 2: Model of UPEC Pathogenesis. (Mobley et al., 2009)

Possible Complication: Bacteremia

Overview:

Bacteremia occurs when a bacteria has entered the bloodstream and is rapidly multiplying.¹⁰ Bacteremia is diagnosed through a blood culture indicating the presence of a pathogenic bacterium. Some cases remain asymptomatic or induce only a mild fever if the rate of replication is low. Bacteremia tends to develop as a secondary infection to primary infections, where the bacteria of the primary infection breaks through tissue to reach the bloodstream.² Primary infections that occur in the lungs, kidneys, stomach, and other organs with easy access to the bloodstream have the potential to develop into bacteremia. Even though most bacteremia is mild and resolves on its own, treatment should be pursued to prevent further development of the infection.¹⁰

Without treatment of bacteremia, though, the infection can progress into sepsis. Sepsis is when the immune system overreacts to the growing infection in the blood. When bacteremia has induced sepsis, symptoms change to include tachypnea, shaking chills, persistent fever, hypotension, and gastrointestinal symptoms including nausea, vomiting, and diarrhea.⁸ When the systolic blood pressure drops below 90 mm Hg or the mean arterial blood pressure is below 65 mm Hg, the patient has entered into septic shock. The body tissues no longer receive adequate levels of oxygen from the bloodstream, leading to potential organ failure. Sepsis is considered a life-threatening emergency due to the possibility of tissue death.¹⁰

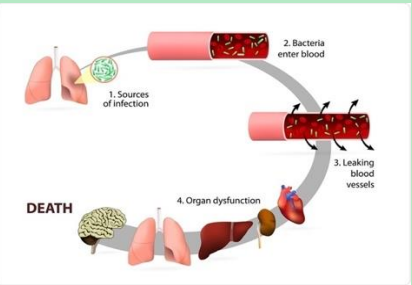
Bacteremia from UTIs:

The UTI is the most common cause of community-acquired bacteremia and subsequent sepsis.⁴ However, in only causes about 3% total of all bases of bacteremia. In 15-40% of patients with UTIs, bacteremia is confirmed upon presentation, though very few cases develop into sepsis. Most healthy adults recover from an *E. coli* bacteremia within one week, but for some people, particularly young children and older adults, the combined bacteremia, sepsis, and UTI can lead to a development of hemolytic uremic syndrome (HUS). A HUS infection causes destruction of red blood cells that can lead to kidney failure.²

Bacteremia from Surgical Procedures:

In the case study, the patient's bacteremia from UPEC is either a result of her UTI infection or the surgical placement of a nephrostomy catheter. The majority of all bacteremia cases result from surgical procedure exposure to the blood or the reuse of unclean medical equipment such as catheters and needles. Normal biota of the body can be introduced into a new body system or organ through traveling on foreign objects being inserted, allowing commensal organisms to become pathogenic.¹¹

Figure 3: Development of bacteremia and sepsis. (Ryding, 2018)



Case Study

Initial Presentation:

Medical records from Lori Smith, author Carrie Elaine Smith's mother, were used to develop this case study. Lori Smith is a 52-year-old woman that initially presented with a 13mm kidney stone at her local emergency department.¹ Smith presented with flank pain, nausea, vomiting, but notably no fever.¹ Smith's medical history includes recurrent urinary tract infections (UTI), type II diabetes, hypertension, and a kidney stone removal 18 years prior.² An initial urine collection was done before Smith was ambulated to a specialty hospital for acute kidney injury and potential kidney failure.³ A urine culture was conducted at the local hospital, but the resulting samples were not sent to the specialty hospital. Smith had an emergency 10mm French nephrostomy catheter placed for urine drainage to prevent kidney failure.⁴ After the surgery was performed, Smith was diagnosed with a UTI, although the development of this UTI is unknown to have started before or after her initial presentation. A second urine collection was performed at the specialty hospital, with the urine culture indicating gram negative rods. A blood sample was analyzed through the OSH Infection Control Program, with results indicating uropathogenic *E. coli*.⁷

Complications:

Smith was initially treated empirically with Zosyn, a penicillin antibiotic, for her UTI before UPEC was identified as the causative agent.² 24 hours after her surgery, Smith began to experience chills, confusion, and violent shaking, with her blood pressure dropping from 105/55 mmHg to 72/55 mmHg. Smith was diagnosed with bacteremia and given 1g ceftriaxone IV every 24 hours along with aggressive rehydration and midline for extreme hypotension.³ The cause of bacteremia could not be determined between the nephrostomy surgery or UTI complications, and culturing of the nephrostomy tube was not performed as removal would risk further kidney damage that could have been fatal. Once the blood culture confirmed UPEC, Smith was continued on a ceftriaxone course and continually monitored for further development.⁷

Treatment:

Within 12 hours of initial treatment for bacteremia, Smith's blood pressure returned to 107/56, and ceftriaxone IV was prescribed as a continual antibiotic for 14 days.⁴ Smith was discontinued on midline for hypotension. Once her kidney health was stabilized, Smith was sent home to await further surgery for kidney stone removal. An IV line remained for the ceftriaxone antibiotic, and a biweekly blood draw was conducted to monitor the infection.⁵

Outcome:

After the two-week antibiotic course, Smith was cleared of her bacteremia, and the antibiotic course was discontinued.⁷ Smith had her kidney stone removed a week after her infection was cleared, and no further complications occurred.⁶ Kidney damage from the stone is continually being monitored, but Smith is expected to make a full recovery. Smith will have future consultations to manage her recurrent UTI complications as preventative for sepsis to occur again.⁵

Conclusion

Escherichia coli is a gram-negative bacillus that is a commensal organism of the gastrointestinal and genitourinary system. *E. coli* is the leading cause of urinary tract infections (UTI), where *E. coli* from feces comes in contact with the urethral opening and starts colonization. *E. coli* causing UTIs are referred to as uropathogenic *E. coli* (UPEC).¹ Infection of UPEC starts in the urethra, moves to the bladder, and can potentially move through the ureters to reach the kidneys. If the infection reaches the kidneys, the bacteria has the potential to enter the bloodstream, leading to bacteremia and potential sepsis. Virulence factors of UPEC include fimbrial adhesion, hemolysin, CNF-1, SAT, and LPS.⁸ UPEC is diagnosed through a urine culture indicating a UTI and a subsequent blood culture for gram negative rods. UPEC infections are common within hospitals, especially after reuse of a catheter introducing it into the bladder. Extreme caution should be used when using medical instruments, including sterilization and avoiding reuse, to prevent UPEC colonization into the bladder or the bloodstream. Proper hygiene is advised as well to prevent UPEC infections from occurring outside of a hospital environment.⁵

References

- Mobley, H. L. T., Donnenberg, M. S., & Hagan, E. C. (2009). Uropathogenic *Escherichia coli*. *EcoSal Plus*, 3(2). <https://doi.org/10.1128/ecosalplus.8.6.1.3>
- Mueller, Matthew, and Christopher R. Tainter. "Escherichia Coli Infection- Statpearls - NCBI Bookshelf." *National Library of Medicine*, National Center for Biotechnology Information, 11 July 2023, www.ncbi.nlm.nih.gov/books/NBK564298/.
- Slack MD, Kenneth V. (2023, October 27). *ED Clinical Summary*. Pensacola, FL: Ascension Sacred Heart Pensacola Emergency Department.
- Dochow DO, Andrea. (2023, October 27). *History and Physical Reports*. Pensacola, FL: Ascension Sacred Heart Pensacola Emergency Department.
- Dochow DO, Andrea. (2023, October 31). *Discharge Documentation: Bacteremia, Adult*. Pensacola, FL: Ascension Sacred Heart Pensacola Emergency Department.
- Keasler MD, Eric M. (2023, October 31). *Operative Documentation*. Pensacola, FL: Ascension Sacred Heart Pensacola Surgical Department.
- Dochow DO, Andrea. ((2023, November 1). *Bacteriology Report*. Pensacola FL: Ascension Sacred heart Pensacola Surgical Department.
- Terlizzi, M. E., Gribaudo, G., & Maffei, M. E. (2017). Uropathogenic *Escherichia coli* (UPEC) Infections: Virulence Factors, Bladder Responses, Antibiotic, and Non-antibiotic Antimicrobial Strategies. *Frontiers in Microbiology*, 8(1566). <https://doi.org/10.3389/fmicb.2017.01566>
- Whelan, S., Lucey, B., & Finn, K. (2023). Uropathogenic *Escherichia coli* (UPEC)-Associated Urinary Tract Infections: The Molecular Basis for Challenges to Effective Treatment. *Microorganisms*, 11(9), 2169. <https://doi.org/10.3390/microorganisms11092169>
- Ryding, S. (2018, December 4). *The Stages of Sepsis*. News-Medical.net. <https://www.news-medical.net/health/The-Stages-of-Sepsis.aspx>
- Park, H. J., Jung, D. Y., Ji, W., & Choi, C.-M. (2020). Detection of Bacteremia in Surgical In-Patients Using Recurrent Neural Network Based on Time Series Records: Development and Validation Study. *Journal of Medical Internet Research*, 22(8), e19512. <https://doi.org/10.2196/19512>
- McLellan, Lisa K. and David A. Hunsford. "Urinary Tract Infection: Pathogenesis and Outlook." *Trends in Molecular Medicine*, U.S. National Library of Medicine, Nov. 2016, www.ncbi.nlm.nih.gov/pmc/articles/PMC5159206/.